

# Single Crystal Silicon Instrument Mirrors

## ---- Goals ----

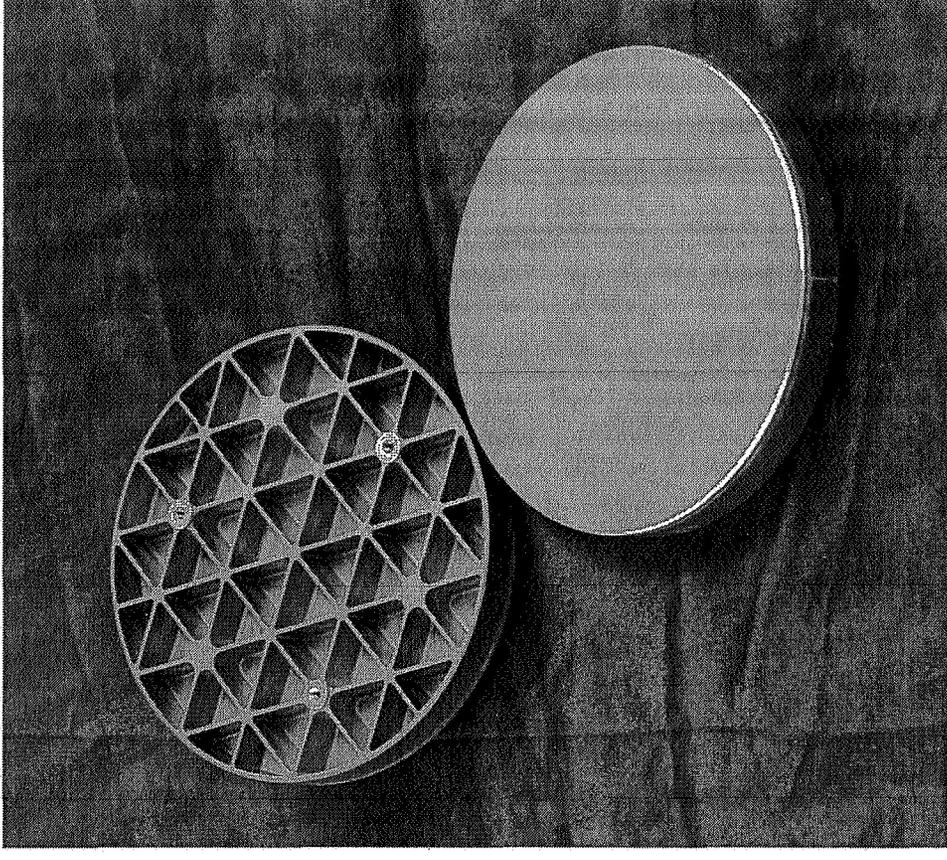
Develop a process for fabricating lightweight mirrors from single crystal silicon (SCS)

Modest lightweighting: 3X to 4X less than equivalent solid mirror

High surface quality, better than  $\lambda/40$  RMS @ 633nm

Significantly less expensive than current technology

Negligible distortion when cooled to cryogenic temperatures



# Single Crystal Silicon Instrument Mirrors

## -- Process --

Form single crystal silicon (SCS) blank

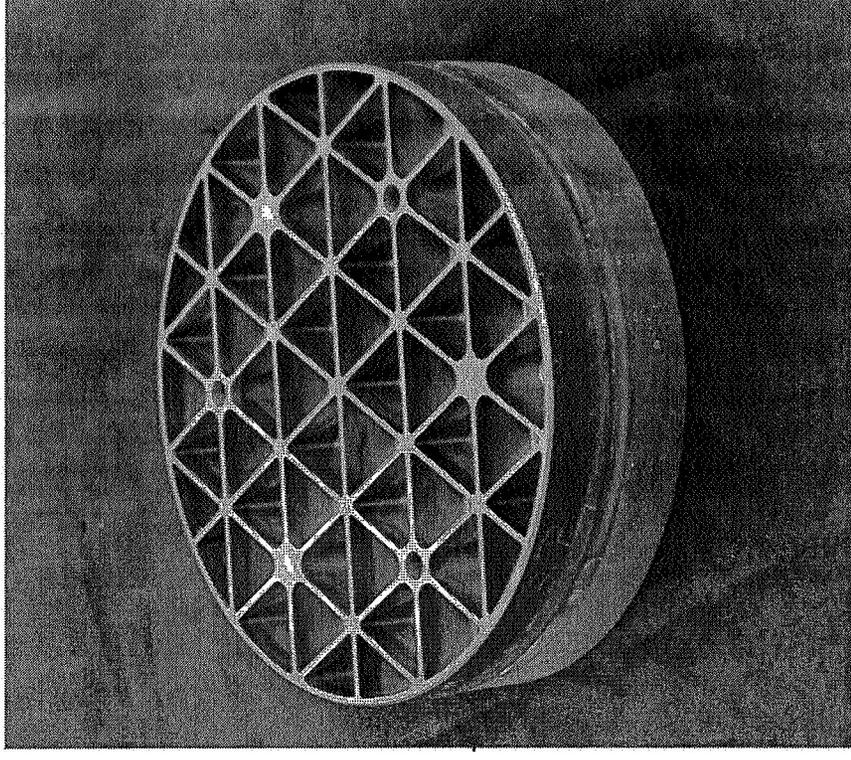
Grind and polish optical surface using \* standard techniques and abrasives

Wax-on temporary Pyrex protector

Lightweight using ultrasonic machining

Post polish if necessary for extreme applications (better than  $\lambda/60$ )

*\* Solid blank without worry of print-through plus hardness/removal rate  $\approx$  fused quartz key to lower cost*



# Single Crystal Silicon Instrument Mirrors

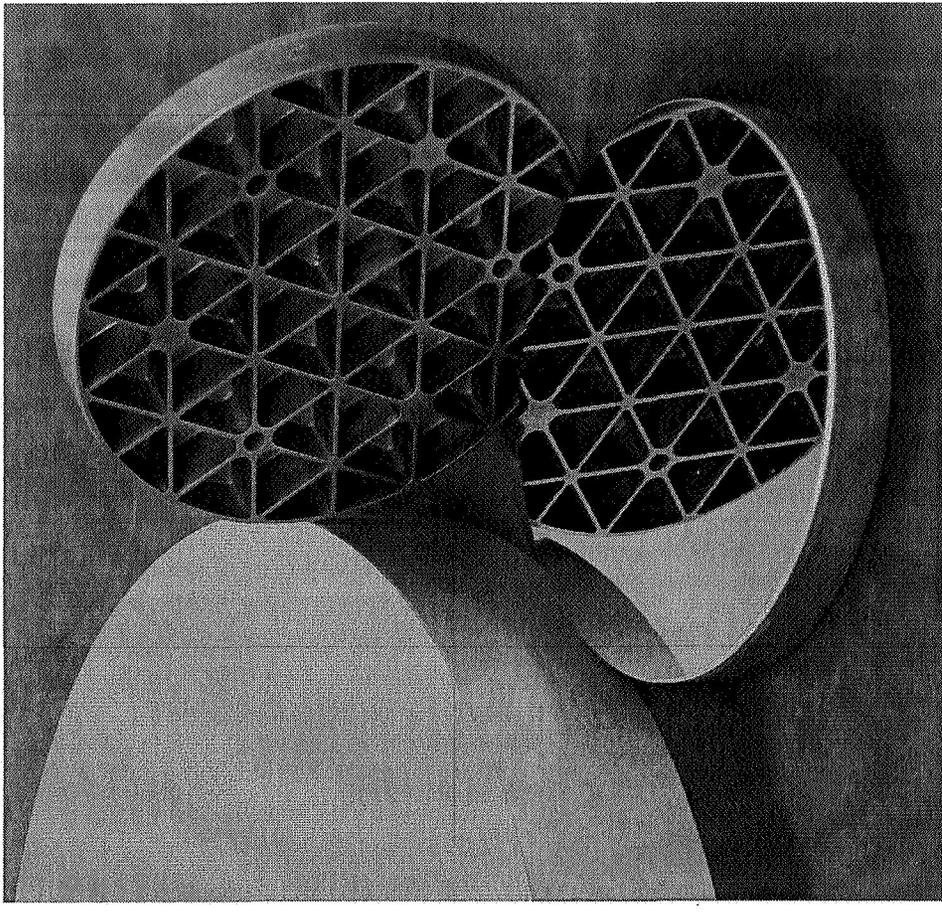
## -- Results --

11 SCS mirrors fabricated ranging in diameter from 10cm to 25cm

Lightweighting after polishing demonstrated to better than  $\lambda/50$

Post polishing demonstrated to  $\lambda/90$  without print -through

Test of cryogenic performance presently underway



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## Lightweighting Process

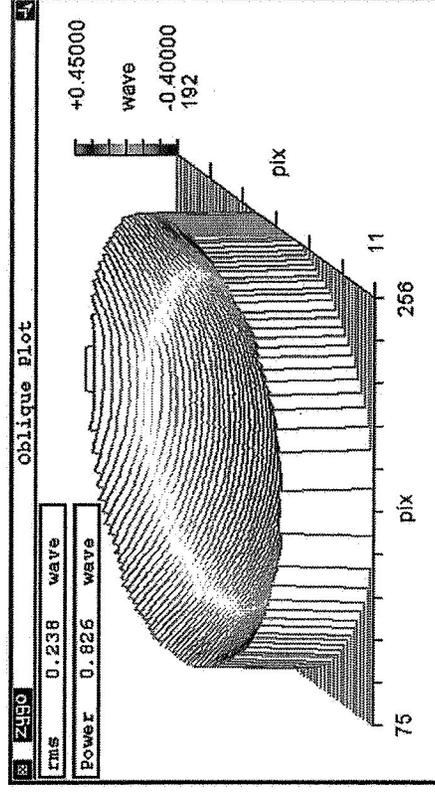
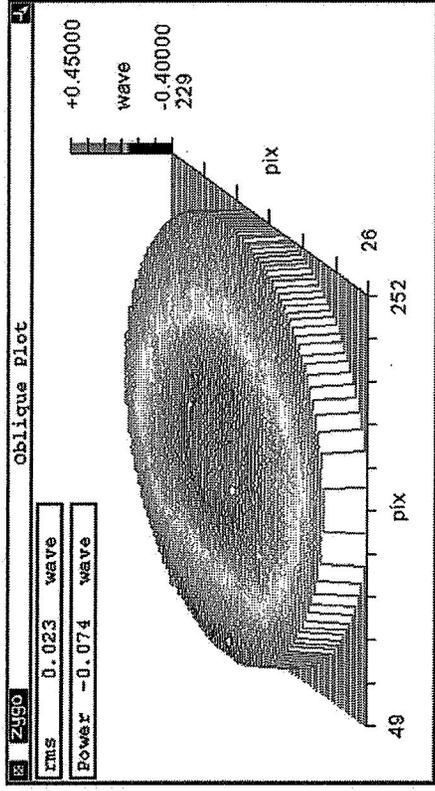


Figure before lightweighting

Figure after lightweighting,  
before heat treating

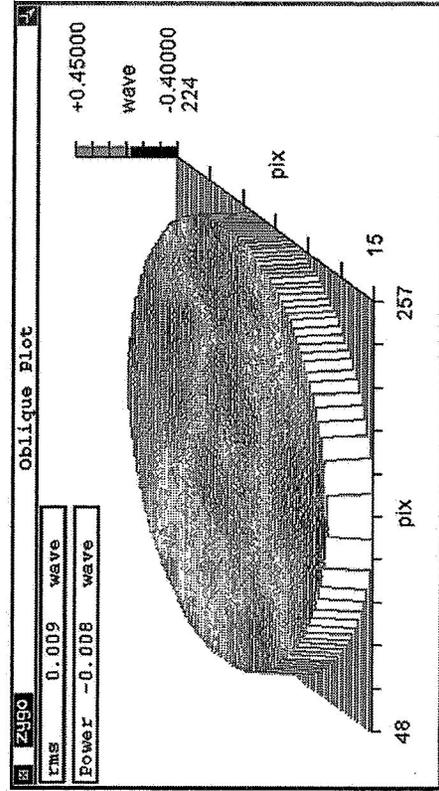
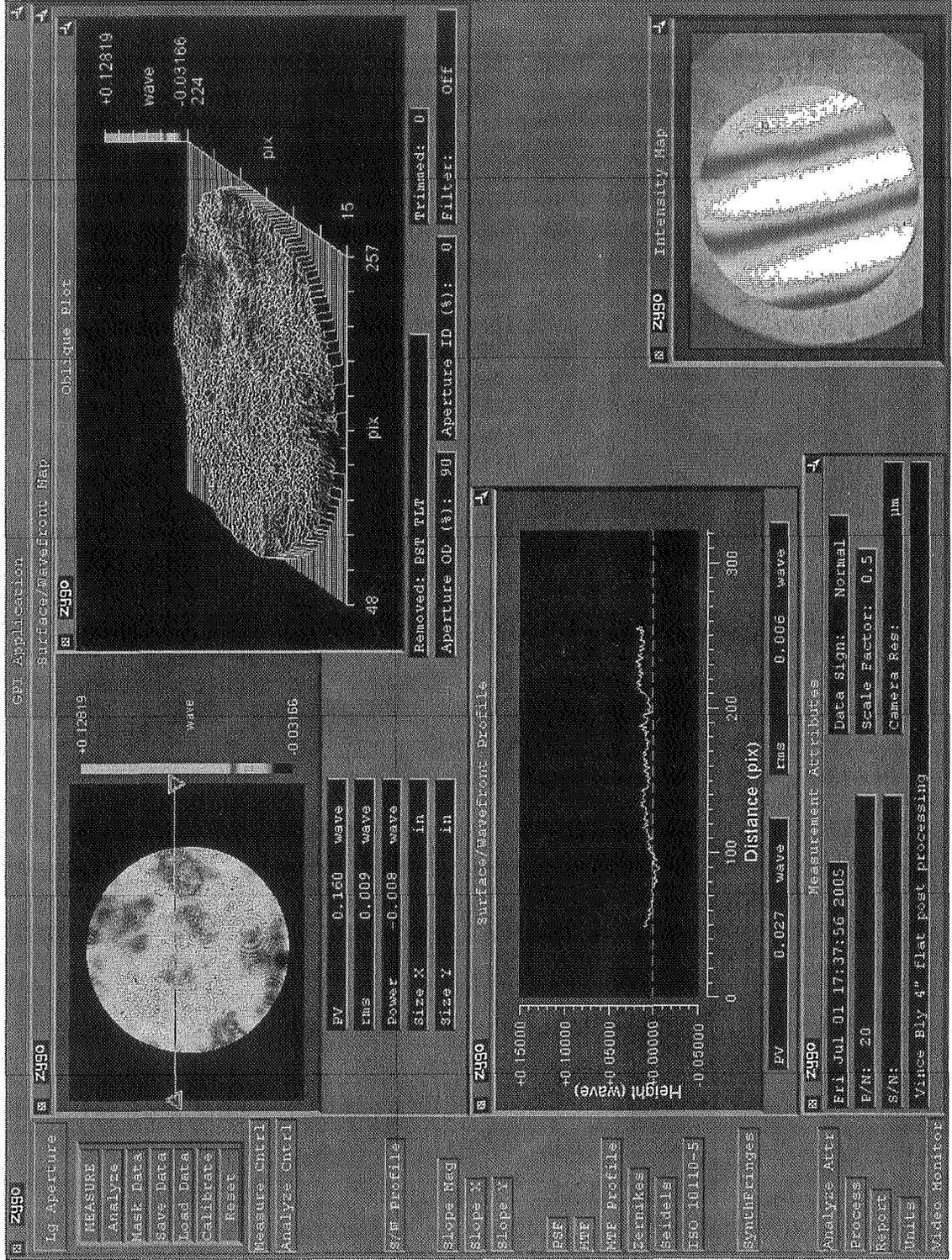


Figure after heat treating

# Single Crystal Silicon Instrument Mirrors

## Interferogram of 10cm (4") SCS Flat #2C



# Single Crystal Silicon Instrument Mirrors

## Interferogram of 10cm (4") SCS Flat #2D

BI Z490

MEASURE Analyze Mask Data Save Data Load Data Calibrate Reset

Measure Ctrl Analyze Ctrl

Surface/Wavefront Map

Oblique Plot

BI Z490

Wave: +0.04747  
-0.03134  
103093

40874 133975 9991

Removed: PST TLT Aperture ID (\$): 0 Filter: Off Trimmed: 0

Aperture OD (\$): 90

BI Z490

Surface/Wavefront Profile

Height (Wave) vs Distance (cm)

PV: 0.079 wave, rms: 0.015 wave, Power: 0.047 wave, Size X: 3.7 in, Size Y: 3.7 in

BI Z490

Intensity Map

BI Z490

Measurement Attributes

Mon May 08 14:38:25 2006  
E/N: 21  
S/N:  
Vance Bly 4" SCS IM Flat

Data Sign: Normal  
Scale Factor: 0.5  
Camera Res: 454.2  $\mu$ m

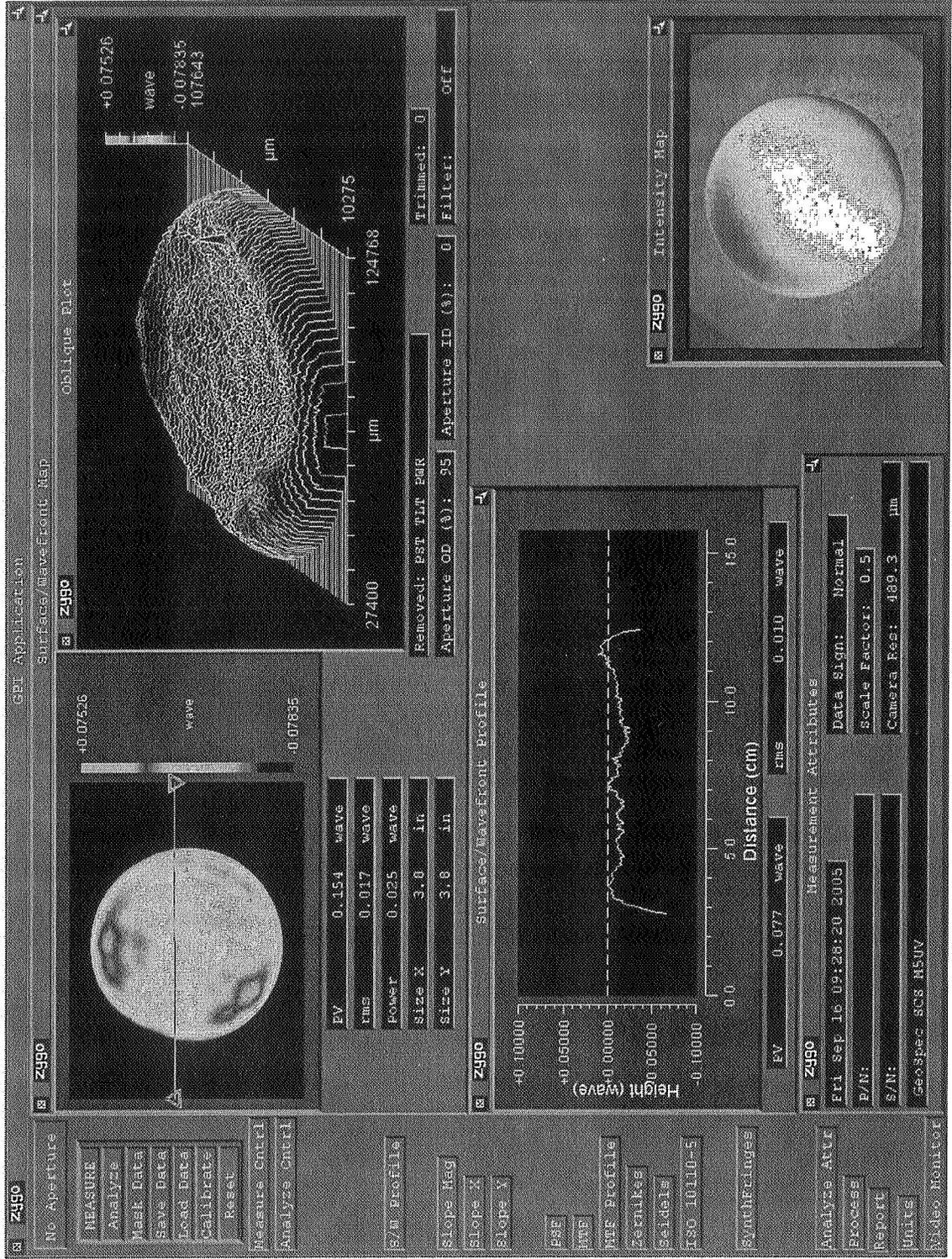
BI Z490

Switch Rings

Analyze Attr Process Report Drive Video Monitor

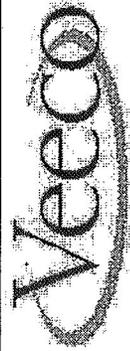
# Single Crystal Silicon Instrument Mirrors

## Interferogram of F/1.2 Spherical Mirror for GeoSpec



# Single Crystal Silicon Instrument Mirrors

## Interferogram of Early Mirror After Post Polishing



### Contour Plot

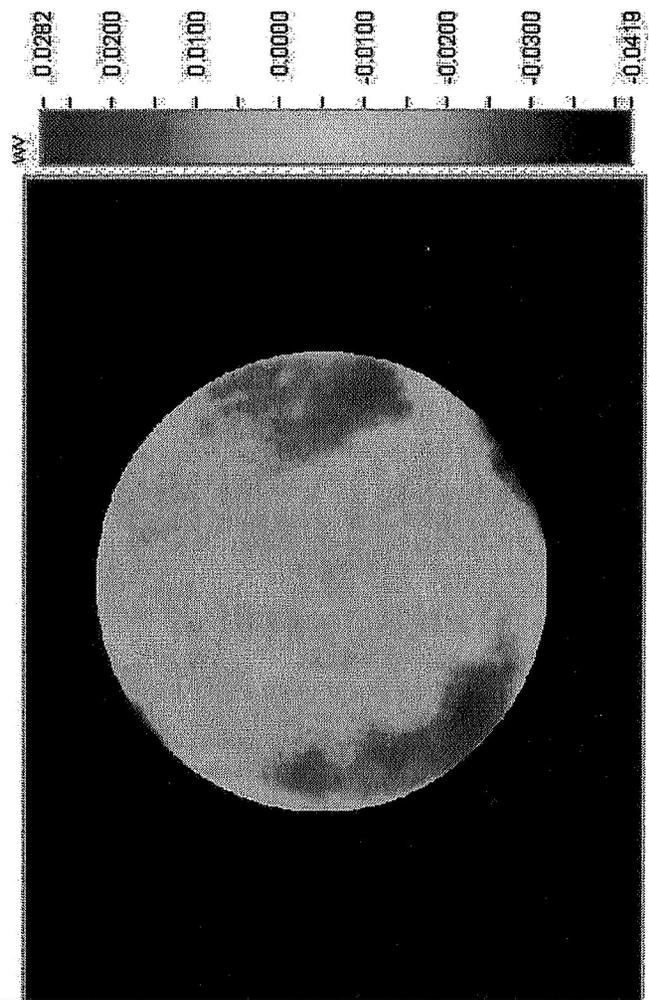
Measurement Parameters	
File:	21Nov02_vb
Wavelength	632.80 nm
Wedge	0.50
XYSize	736 X 480
Pixel size	0.00 um
Date	11/21/2002
Time	14:36:48
Averages	4

Analysis Results	
Ra	0.009 wv
Rms	0.011 wv
20 Pt. PV	0.067 wv
2 Pt. PV	0.07 wv

Analysis Parameters	
Terms	Tilt
Masks:	None
Filtering	No
Data Restore	113443
Valid Points	



Title: SCS Mirror 2A @90% aperture

# Single Crystal Silicon Instrument Mirrors

## -- Future Work --

Complete cryogenic testing and publish results

Demonstrate perforated primary

Demonstrate off-axis asphere using diamond turning or Zeeko process

Optimize lightweighting process for larger (>20cm) mirrors

